### Medical Science.

*Bailliere, Tindall and Cox.*—Field Sanitation, Capt. C. G. Moor, illustrated; The Organs of Internal Secretion: their Diseases and Therapeutic Application, Dr. I. G. Cobb; Physical Remedies: being Practical Treatment by Mechanical Apparatus, such as Exercise and Medical Gymnastics, Heat and Cold in Baths, Electricity, Radiation, and Massage, Dr. R. F. Fox, illustrated; The Pituitary Gland, Dr. R. B. Bell. *Cambridge University Press.*—The Spread of Tuberculosis, Dr. L. Cobbett (Cambridge Public Health Series). *Cassell and Co., Ltd.*—The Nation's Health, Sir Malcolm Morris; Electrical Treatment, Dr. W. Harris, new edition, illustrated. *J. and A. Churchill.*—New editions of Sanitation in War, Major P. S. Lelean, illustrated; and Minor Surgery and Bandaging, H. M. Davies. *Constable and Co., Ltd.*—Health and the State, Dr. W. A. Brend. *W. Heinemann.*—Malingering; or, The Simulation of Disease, A. B. Jones and Ll. J. Llewellyn, with a chapter on Malingering in Relation to the Eye, W. M. Beaumont; Painless Childbirth: A general survey of all painless methods, with special stress on "Twilight Sleep" and its extension to America, M. Tracy and M. Boyd; Studies in Forensic Psychiatry, Dr. B. Glueck (Criminal Science Monographs); Cerebellar Abscess: its Etiology, Pathology, Diagnosis, and Treatment, including Anatomy and Physiology of the Cerebellum, Dr. I. Friesner and Dr. A. Braun. *Longmans and Co.*—The Physiology of Food and Economy in Diet, Prof. W. M. Bayliss; The Secretion of Urine, Prof. A. R. Cushny. *Macmillan and Co., Ltd.*—Human Physiology, Prof. L. Luciani, translated by Frances A. Welby, with a preface by Prof. J. N. Langley, illustrated, in 5 vols., vol. iv., edited by Dr. G. M. Holmes. *Masson et Cie* (Paris).—Collection de Précis de Médecine et de Chirurgie de guerre:—Traitement des Fractures, R. Leriche, tome ii.; Hystérie-Pithiatisme et Troubles nerveux d'ordre réflexe en Neurologie de guerre, J. Babinski and J. Froment; Psychonévroses de guerre, Drs. G. Roussy and J. Lhermitte; Blessures de la Moelle et de la Queue de cheval, Formes cliniques et anatomiques, Traitement, Drs. G. Roussy and J. Lhermitte; Traitement et Restauration des Lésions des Nerfs, Mme. Athanassio-Benisty; Blessures du Crâne et du Cerveau, Formes cliniques et Traitement médico-chirurgical, C. Chatelin and de Martel; Les Fractures de la Mâchoire inférieure en Chirurgie de guerre, L. Imbert and P. Réal; Les Fractures de l'Orbite par Blessures de guerre, Prof. F. Lagrange; La Prothèse des Membres en Chirurgie de guerre, Prof. A. Broca and Ducroquet; Localisation et extraction des projectiles, Prof. Ombrédanne and R. Ledoux-Lebard; Guide pratique du Médecin dans les Expertises médico-légales militaires, Ducos and Blum. *Methuen and Co., Ltd.*—Tuberculosis, Dr. C. Riviere (Methuen's Health Series).

### Technology.

*Cambridge University Press.*—Experimental Building Science, J. L. Manson, vol. i., Naval Architecture, J. E. Steele. *Constable and Co., Ltd.*—Wool, F. Ormerod, illustrated. *Crosby Lockwood and Son.*—In the "Books for Home Study" Series: Automobile Driving and Repairs, Hall and Cravens; Foundry Work, Gray; Refrigeration, Arrowood; Plumbing, Gray and Ball; Patternmaking, Ritchey and Monroe. *John Murray.*—Cotton and other Vegetable Fibres, Dr. E. Goulding (Imperial Institute Handbooks). *Scott, Greenwood and Son.*—Elementary Mathematics for Engineers and Architects, E. H. Sprague; Calculations for Steel Frame Structures, W. C. Cocking; Driving of Machine Tools, T. R. Shaw; Design of Machine Elements, W. G. Dunkley, 2 vols.; Elements of Graphic Statics, E. H. Sprague; Strength of Structural Elements, E. H. Sprague; Portland Cement: its Properties and Manufacture, P. C. H. West; Gear Cutting, G. W. Burley; Moving Loads by Influence Lines and other Methods, E. H. Sprague; Drawing Office Practice, W. Clegg; Estimating Steelwork for Buildings, B. P. F. Gleed and S. Bylander; The Theory of the Centrifugal and Turbo Pump, J. W. Cameron; Strength of Ships, J. B. Thomas; Machine-shop Practice, G. W. Burley; Iron and Steel, J. S. G. Primrose; Electric Traction, H. M. Sayers; Precision Grinding Machines, T. R. Shaw. *Whittaker and Co.*—International Technical Dictionary in English, French, Italian, and German, E. Webber.

### Miscellaneous.

*A. and C. Black, Ltd.*—An Introduction to the Physiology and Psychology of Sex: an Outline for Beginners, Dr. S. Herbert. *Cambridge University Press.*—Comptes Rendus of Observation and Reasoning, J. Y. Buchanan; Science and the Nation: Essays by Cambridge Graduates, with an introduction by Lord Moulton, edited by Prof. A. C. Seward; The Combination of Observations, D. Brunt. *Cassell and Co., Ltd.*—Psychical Investigations, J. Arthur Hill; The Borderlands of Science, Dr. A. T. Schofield. *Chapman and Hall, Ltd.*—Handbook for Rangers and Woodsmen, J. L. B. Taylor. *Wells Gardner, Darton and Co., Ltd.*—Story Lives of Great Scientists. *Macmillan and Co., Ltd.*—The Economic Annals of the Nineteenth Century, the late Prof. W. Smart, vol. ii., 1821–1830. *John Murray.*—The War and the Nation: a Study in Constructive Politics, W. C. D. Whetham. *Smith, Elder and Co.*—The Life and Letters of Sir J. D. Hooker, O.M., G.C.S.I., L. Huxley, 2 vols. *Watts and Co.*—The Origin of the World, new and cheaper edition.

---

## *RESEARCH IN INDUSTRIAL LABORATORIES.*[1]

### *The Organisation of Industrial Research.*

It is generally conceded by those engaged in the direction of industrial research that, in order to be efficient, research laboratories of this type should be as thoroughly equipped as possible. In the case of industrial concerns having a number of plants and in the case of organisations of manufacturers, the tendency of organisation should undoubtedly be towards concentration and co-operation in the maintenance of one large well-equipped research laboratory, rather than towards the erection and support of a number of smaller separated laboratories. It is, of course, necessary, especially in the case of chemical plants, that the analytical and control work should be carried out *in situ*, but experience indicates that it is much better practice to centralise the research work.

Since the policy which ensures adequate guidance to a research organisation must be based upon the accumulation of facts, method in laboratory administration should provide for facilities for securing detailed information on a vast field, and for competent counsel from those who have a store of specialised knowledge. When the laboratory executive's work has passed the one-man stage, a division of labour comes about, and it is here that he must see to it that he surrounds himself with men who are capable of effective effort—alert, original investigators of initiative and leadership.

An organised research administrative staff should result not only in effective division of labour, but also in efficient expenditure of executive energy, more effective plans, and general stabilisation. This can come about if there is a pervading organisation type of mind, which "is common to those drilled in systematic thinking and long immersed in the materials of their particular vocation. Such a mind sees details, but only as parts of a whole; reaches generalisations, but by the inductive route."

---

[1] Report of a Sub-committee on Research in Industrial Laboratories, consisting of Drs. R. F. Bacon (chairman), C. E. K. Mees, W. H. Walker, M. C. Whitaker, W. R Whitney, and presented at the meeting of the Committee of One Hundred on Scientific Research, New York, of the American Association for the Advancement of Science, December 26, 1916.

With regard to the investigatory staff, while the individual can exert only a very small influence except as a member of an organisation or institution, yet a research institution never gains note or influence except through the attainments and achievements of its individual members. The research department of a large industrial concern will be great because it has investigators on its staff who possess great originality and ability and because its director is wise and far-sighted. It is generally conceded that the personal factor is always paramount in industrial research, and that, as in every other organisation, the control of men is the real problem in laboratory administration.

A brief consideration of the conditions favourable to both pure and industrial research is pertinent in connection with any discussion of the personal organisation.

It is particularly adverse to progress to regard able investigators as abnormal men; for successful research demands neither any peculiar conformity nor any peculiar deformity of mind, but it requires, rather, peculiar normality and unusual industry and patience. It is little less inimical to expect productive work from those who are absorbingly preoccupied with other affairs than research; for fruitful scientific inquiry entails, in general, prolonged and arduous, if not exhausting, labour, for which all the researcher's time is none too much. This is the experience of the Carnegie Institution and all other research organisations. It is only to be expected, therefore, that those most likely to produce important results in research are those who have qualified for the responsibilities thereof by the completion and publication of several worthy investigations, and who are at the same time able to devote the bulk of their energies thereto. The productive researchers in our universities are those who are devoting their whole time, or practically their whole time, to investigatory work.[2]

Research should never be allowed to fall into the rut of prosaic routine. The *personnel* of the investigatory staff should be maintained at the very highest standard, and all administrative plans should be carried out with enthusiasm and earnestness.

In the research laboratories of manufacturing plants the personal co-operation of the research staff with the members of other branches of the organisation always proves an important aid in maintaining interest in the work and is, in addition, mutually educating.[3] In particular, the research department should have an *esprit de corps* that keeps things moving and should lead the way so strikingly as to be apparent to all other departments of the corporation. In consequence, mediocrity should never be tolerated. It should be borne in mind, however, that the research man can only accomplish efficient work when he is free from restraint and petty annoyances.

Co-operation is always contributory to success in a research laboratory, and, other conditions being equal, the valuable men are the ones who can and will co-operate with one another. As in business, men succeed only as they utilise the ideas and services of other men. It follows, therefore, that the strength of an investigatory staff, properly operated, should increase more rapidly than the increase of its numbers, and that a fraternal spirit will play an important *rôle* in the productiveness of any research department.

The experience in several of our most successful industrial research laboratories has clearly shown that co-operation between the different departments thereof can be adequately and completely obtained by well-planned weekly conferences on the subjects under study. While some directors of industrial research hesitate to spend the time which these conferences entail, it is the opinion of the sub-committee that conferences of this nature are worth far more than the time they take.

### *The Selection and Training of Students for Industrial Research*

Research leading to the discovery of new ideas requires not only intellect and training, but also initiative or genius; it can come only from an individual who possesses unusual intuition and insight. It follows, therefore, that there is a scarcity of men gifted with the genius for industrial research, and that it requires much experience in selecting suitable men and in training them to the desirable degree of efficiency, after having determined the particular qualities required.

The important requisites for industrial research are often unconsidered by manufacturers, who, in endeavouring to select a research chemist, are likely to regard every chemist as a qualified scientific scout. The supply of men capable of working at high efficiency as investigators is well below the demand; and chemists having the requisites and spirit of the researcher are indeed difficult to find even by those experienced in the direction of research. All research professors know that the location of a skilled private assistant—one who possesses not only originality, but also sound judgment and intellectual honesty—is not easy, because it frequently involves the gift of prophecy on the part of the searcher.[4] It has been truly said that the "seeds of great discoveries are constantly floating around us, but they only take root in minds well prepared to receive them."

On account of the extraordinary importance of new ideas, particular emphasis should always be laid upon finding and supporting brilliant researchers. Such individuals can best be found in the universities. The function of the university is to work with the beneficent idea of increasing the sum of human knowledge, and among its most valuable products are those who will work for the exercise of the investigative instinct and the pleasure of overcoming difficulties.

The examination of the training necessary for those proposing to take up industrial research which is common with all scientifically trained men, is too extensive a subject to be discussed by the sub-committee at this time. It is, however, appropriate to consider those subjects in which it seems desirable for the prospective researcher to specialise: reference is, of course, made to subjects other than those required by the average student of the sciences as distinguished from their industrial application, but the assumption is not made that what is desirable for research work should not also be available for all.

Research men frequently possess adequate training and scientific acumen, but fail in their ability to use such. There is no question that the element most noticeably lacking in the modern graduate is *resourcefulness.* A qualified research chemist who possesses initiative is usually a creator; but owing to the neglect of existing difficulties in chemical pedagogy, the present-day graduates of our schools of chemistry are too often deficient in inspiration, ingenuity, and insight.

---

[2] As a rule, the head professors of chemistry in the larger universities are not giving more than three to five hours of lectures during the week, the rest of their time being devoted to research, while a number of them have one or more private research assistants, besides the candidates for advanced degrees, doing research work.

[3] In several of our largest corporations the plant superintendents make monthly reports to the research departments, including all ideas of their own or of their assistants which may in any way warrant investigation. Then, too, the salesmen report regularly to the research department regarding the various ways in which the company's products are used and what substitutes are employed for the company's products. Such plans stimulate closer thought and observation.

[4] See discussion in *Science*, N.S., 41 (1915), p. 319.

The failure to provide adequate and systematic instruction in chemical literature is illustrative of this contention.

Before commencing laboratory work upon any problem, it is obviously necessary to digest intelligently the important contributions which have been made upon the subject and to take advantage of what other workers have done in the same field. The average graduate is usually almost helpless when attempting to do this, and consequently requires close supervision. The main difficulties are:—

(*a*) He does not know how to go about it; he does not know where to look as the most probable source; and he is not familiar with the standard treatises and important journals.

(*b*) He fails to analyse the subject into its factors and hence generally looks for topics which are too general. Because he does not find any reference to the problem as a whole as he has it in mind, he assumes that nothing has been done upon it and that there is nothing in the literature which will be of aid to him in the investigation. Were he to separate his subject into its essential parts and then to consult the literature on each factor, he would find considerable information which he otherwise would miss.

(*c*) He does not critically digest the articles under examination, but often he makes only a few disconnected quotations and fails to interpret the work done.

The solution is to be found in the provision in the chemical curriculum, preferably in the senior year, of a course of lectures on the literature of chemistry, with particular reference to the character of the writings and the status of the authors. The purpose of these lectures should be to present a general survey of the voluminous literature and to impart an accurate, systematic working knowledge of chemical bibliography. A concurrent seminar should be devoted to indexing and tracing chemical literature, to the cultivation of an acquaintanceship with authorities, and to the solution of bibliographic problems.

The sub-committee also recommends that pedagogic attention be given to the arrangement of a course of study in the principles of technical reporting and in the criteria of literary excellence in the preparation of reports of researches and professional reports. The completion of such a subject, with its accompanying analysis, practice, and criticism, would usefully supplement the training received in chemical bibliography and would develop a capability which is much needed by chemical graduates.

It may be noted in passing that, during the academic year 1914–15, distinct courses in chemical literature and in technical reporting were established at the University of Pittsburgh. Much success has attended this pedagogic innovation.

The chemical graduate of to-day is also deplorably deficient in resourcefulness in planning research. While this is an extensive subject, a research student may be trained in correct methods of attack, namely:—

(*a*) *Analytical Methods.*—Almost all investigations require analytical control. In no feature of chemical work is there more apparent an inability to use the analytical training which the man has received.

(*b*) *Planning the Investigation.*—Resourcefulness in separating a problem into its essential factors and in clearly grasping the inter-relationship of these factors is most important. Too many men desire to start in at once and solve the problem at the first attempt All this might be summed up in the expression "methods of research."

(*c*) *Apparatus.*—The sub-committee has not considered just how a man could be trained to be more resourceful in this respect, but it is surely a marked weakness in the average graduate. While a native cleverness is doubtless born, and not made, it ought to be possible to give the undergraduate some training in the use of his mental equipment in designing and planning apparatus which is to accomplish the desired end.

### *The Factors involved in the Promotion of Co-operation between Manufacturers and the Universities.*[5]

The recent impetus imparted to the research activities in American chemical manufacturing has materially altered the traditional policy of industrial secrecy. A striking illustration of this improvement is to be found in the reports of the Industrial Conferences held at the fifty-third meeting of the American Chemical Society.[6] This change in attitude, a natural result of the appreciation of urgent action in industrial research, has long been desired by our universities, and it will undoubtedly result in the extension of the practice of referring certain of the problems of industry to university laboratories for study. Many of the numerous problems of chemical as well as mechanical technology could be advantageously attacked outside of the plants, but some central organisation is needed for securing and properly distributing those problems which are pressing. It is clear, however, that stable relations between the universities and industrialists will be worth while only if some mutual benefit can accrue therefrom. This co-operation can therefore be most satisfactorily promoted by actively demonstrating the advantages of the exchange or interchange of subjects for research, which primarily presupposes a reasonable freedom from the concealment of knowledge which persistently adheres to all industrial research.

Industrial research laboratories can be of mutual aid by supplying advice and materials. These laboratories should also publish reports of investigations just as freely as possible and thus, by proving the utility of it, assist in the general scheme of the universities—promote the dissemination of knowledge.

In general, the sub-committee endorses the conclusions of the University and Industry Committee of the New York Section of the American Chemical Society.[7]

### *The Promotion of a Better Appreciation of Research.*

The promotion of a better appreciation of research by the general public can only be obtained by publicity.[8] No complaint can be made of a lack of this at the present time. The large corporations supporting industrial laboratories are themselves expending great sums on giving publicity to their research work. The sub-committee thinks, however, that though the general public now appreciates the value of scientific research, the thing required to increase the number of laboratories is more information as to specific plans for starting and running them. General articles on the advantages of research work would be very much helped in carrying conviction if they were accompanied by definite proposals telling manufacturers of different industries and of different grades in the size of their work what they could do in the way of research work themselves.

---

[5] The president of the American Chemical Society has been authorised to appoint a central committee from representatives of the universities and the industries to study opportunities and to make recommendations for co-operation.

[6] See *J. Ind. Eng. Chem.*, 8 (1916), pp. 947 *et seq.*

[7] See *J. Ind. Eng. Chem.*, 8 (1916), p. 658.

[8] It is important to mention here that the American Chemical Society has under consideration the publication of a journal of popular chemistry, a periodical for which there is a real need because of the desirability of the proper dissemination of chemical information to the public.

The average person who has to decide whether his corporation will support research work can, in the nature of things, know little about it. He desires either to spend much less than is necessary for effective work, or he is frightened by the size of the expenditure which he thinks will be necessary. More specific information would enable him to form a truer idea as to what he was committing himself and what he was likely to get.

So far as possible, arrangements should be made for research institutions to have information as to their work available and to persuade them to give this information freely to inquirers. It would be a considerable step in co-operative effort if all the research institutions that can be reached could be persuaded to put information regarding themselves into some form so that a comparison could be made.

### *The Establishment of Stable Relations between Research Institutions and the Research Departments of Industrial Plants.*

The suggestion has been frequently made that the establishment of stable relations between the types of organisations mentioned might be effected if a small group of selected representatives thereof could arrange to confer at regular times. After consideration, the sub-committee recommends the formation of an association of research institutions—that is, an association of all those bodies engaged in scientific and scientific industrial research, including such organisations as the research laboratories of Harvard University, the Massachusetts Institute of Technology, and other educational institutions, the Carnegie Institution laboratories, the Mellon Institute of Industrial Research, and the research laboratories of the corporations which are conducting a certain amount of research of scientific importance. Undoubtedly, an association of this nature would meet with satisfactory support, and it would eventually prove an important factor in improving the methods of research organisation.

Stable relations between various research organisations will be worth while only if some mutual benefits can accrue. These can be brought about by an exchange or interchange of "commodities," such as—

(*a*) Subjects for research.

(*b*) Special facilities for extraordinary conditions, such as extreme pressures, extremes of temperatures, etc.

(*c*) Special pieces of expensive apparatus.

(*d*) Helpful ideas on research already in progress.

(*e*) Candidates for employment.

This presupposes a freedom from the secrecy which still surrounds the industrial research of certain organisations. Undue secrecy is unnecessary and unwise, but it is only in those cases where publicity is compatible with industrial progress that full co-operation between the universities and the industries can be effected.

### *A Comparative Study of Investigational Activities.*

This study would be distinctly worth while, but before the initiation of such a movement there must first be established more mutual confidence than now exists. A comparative study of this kind would be very difficult and would necessitate the expenditure of much time. Probably such information could be secured by obtaining the reports regarding the industrial research laboratories in operation, and there is no reason why a suitable questionnaire could not be prepared and distributed, in order to obtain information regarding research conditions and comparative data relating to the organisations maintaining laboratories.

It would be very useful indeed to have available a year-book pertaining to research laboratories, with the following lines of information: institutions, organisations or concerns supporting them, approximate purpose of laboratory, divisions of science represented therein, manufacturing facilities directly associated therewith, approximate annual expenditure for maintenance of research, number, and particulars relating to the training, of the members of the investigatory staff, and, finally, a list of the scientific publications for the past year. Such a book might also advantageously include mention of the special equipment of the laboratories unlikely to be possessed by every similar institution.

The National Research Council, through its committee on research in educational institutions, could well arrange to have some one whose sole duty it was to co-ordinate the work in university laboratories with reference to general or national welfare. While any attempt which may be made by a national society or association to secure co-operation between industrial and institutional laboratories will invariably encounter the difficulty of vested interests, an organisation with Governmental support might accomplish much fruitful research work through institutions of learning and in such a way that this would be of material benefit to the institutions concerned, as well as to the nation.

R. F. BACON,
*Chairman,*
C. E. K. MEES,
W. H. WALKER,
M. C. WHITAKER,
W. R. WHITNEY.

Pittsburgh, Pa.,
December 15, 1916.

---

## UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—On February 6 Convocation passed, *nem. con.*, a series of decrees providing for the administration of the important bequest received under the will of the late Christopher Welch, M.A., of Wadham College. The income derived from the trust is to be applied to the establishment of four scholarships, each of the value of £100 a year, for the promotion of the study of biology, and more especially for the encouragement of such students as give proof of capacity for original observation and research. Each scholarship is to be tenable for four years, and candidates may offer any one of the subjects botany, animal physiology, and zoology. The bequest is a valuable addition to the means at the disposal of the university for the promotion of scientific research.

The report of the Committee for Anthropology, lately issued, gives an account of the instruction offered during the past year in physical and social anthropology, geographical distribution, prehistoric archæology, and technology. Despite unfavourable conditions, eight fresh students entered their names on the register during the year.

MR. E. J. C. RENNIE, son of Prof. Rennie, of the University of Adelaide, has been appointed acting lecturer in electrical engineering in the University of Melbourne. He will take the place of Mr. E. B. Brown, who is about to engage in munition work in this country.